Chapter 8: Hypernotes

☞WWW☜ 8:1

There are three pictures side by side in Debré (1998a), and in each Pasteur's left hand lies in the identical position, presumably placed there not by Pasteur himself but by a helper.

☞WWW☜ 8:3

Mach described the fit as ‘apoplectic’ (Mach, 1914 p.175), although probably little weight should be put on that, any more than the description of Pasteur’s stroke as a ‘haemorrhage’ – diagnostic methods were far from sophisticated at the time, and is still difficult clinically without the help of a CT scanner. Both Mach and Pasteur are typical in their description of the absence of any pain or other awareness inside the head while the brain damage was occurring. Neurosurgeons routinely cut and manipulate the exposed brain of conscious patients without it being anaesthetised and without the patients being aware of it.

Mach had extremely limited recovery of his right hand: “Over the flexors of this hand I have acquired a very slight control, but over the extensors none at all” Mach, 1914 p.176.

☞WWW☜ 8:4

Although Scott himself said he was born on August 15th, 1771, a recent biographer has suggested that he was actually born in 1770 (Anderson, 1976). I have used Scott's own date here.

Watson's presence on the boat journey to Scotland is described in his own obituary (Anonymous, 1882), and also by Scott's biographers (Sutherland, 1995 p.354), although in one he is erroneously called James Watson, presumably a confusion with Captain James Watson, R.N (Johnson, 1970 p.1267). Watson, apparently nicknamed 'the physician of the novelists' (MacNulty, 1933) seems to keep appearing throughout the present book, rather like Woody Allen's *Zelig*, often where the action is but never quite seeming to be part of the big plot. Although some authors have apparently suggested that Watson continued to Abbotsford with Scott, that does not seem to be the case (MacNulty, 1933) and he returned to London after Scott was safely arrived at Leith (Lockhart, 1896 p.751).

Anderson (1976) has speculated that Scott may had been disease of the right internal carotid artery, which would in part account for the fluctuating course of the illness. On a tiny but important detail, it is worth nothing that Scott was right handed, a portrait sketch by Sir Edwin Landseer in the National Portrait Gallery showing Scott writing with his right hand.

The full post-mortem report for Scott can be found in MacNalty (MacNulty, 1933).

☞WWW☜ 8:5

Illiterate patients also have the same patterns on dichotic testing (Castro & Morais, 1987); see also Lecours *et al* (1988). The question of illiteracy and aphasia was raised by Macdonald Critchley in 1956 (Lecours, 1980 p.600), although Eduard Weber (1806-1871) was apparently the first to ask about the issue (Coppens, Parente, & Lecours, 1998 p.191).

The full Hippocratic text, from *The Coan prognosis*, is, "When a convulsion is attended by prolonged aphasia, it is a bad sign; if such aphasia be short-lived, it is associated either with paralysis of the tongue, or of the arm and right side of the body. The trouble is ended by the sudden passage of a large quantity of urine at one time"(Chadwick & Mann, 1950 p.248). The last sentence about the large quantity of urine seems utterly mysterious from a modern point of view and must make one wonder how much trust can be placed in the first sentence. Hippocrates also described a case history of a pregnant woman with a fever (*Epidemics I, Case XIII*: Howard & Hatfield, 1987, p.8):

> "Pain in the neck and in the head and in the region of the right collar-bone. Quickly she lost her power of speech, the right arm was paralysed, with a convulsion after the manner of a stroke... Fourth day. Her speech was recovered but was indistinct...".

Case of language loss and right-sided motor problems were described as early as 1830, for instance the patient Robert Delany, described by Osborne (1834),

> "... admitted into Sir Patrick Dun's Hospital, 2nd March 1830, with paralysis of the right and leg, in consequence of an apoplectic seizure, which took place above a month previously. He shewed by his actions, that he perfectly comprehended every thing that was said to him. When asked a question, he always endeavoured to give an answer, but could only say *bon te utt* and a few other monosyllables, but no words of more syllables."

Goethe's *Wilhelm Meister* (Carlyle, 1874) was translated in 1824 by Thomas Carlyle, who would later publish his own evolutionary theory of the origin of right-handedness (the 'shield theory' – see chapter 10). Goethe's description, to some extent like that of Jeanette Winterson, has the detail which suggests the account is based on a strong carefully observed personal experience. It has a careful description of the problems of aphasia for patients and their relatives:

> "We had to guess at everything that he required; for he never could pronounce the word that he intended. There were times when this was dreadfully afflicting to us; he would require expressly to be left alone with me; with earnest gestures, he would signify that eery one should go away; and when we saw ourselves alone, he could not speak the word he meant. His impatience mounted to the highest pitch: his situation touched me to the inmost heart. Thus much seemed certain: he had something which he wished to tell me, which especially concerned my interest. What longing did I feel to know it! At other times I could discover all things in his eyes: but now it was n vain. Even his eyes no longer spoke. Only this was clear; he wanted nothing, he desired nothing; he was striving to discover something to me, which unhappily I did not learn. His malady revisited him; he grew entirely inactive, incapable of motion, and a short time afterwards he died."

Charles Dickens has also been claimed to have noticed the association of language dominance and right sided paralysis. A brief article in the *British Medical Journal* after the author's death, "he anticipated the clinical researches of M. Dax, Broca and Hughlings Jackson, in the connection of right hemiplegia with aphasia (*vide Dombey and Son*, for the last illness of Mrs. Skewton)." (Anonymous, 1870a). The story was also repeated in a biography that Dickens had anticipated "connection of right hemiplegia with asphasia [*sic*]" (Anonymous, 1870b). However while in chapter 37 Mrs Skewton was undoubtedly paralysed,

and at times unable to talk, and when the use of her right hand returned, she was able to write, there is no clear description of this being a hemiplegia, rather than a bilateral paralysis, and the final illness in chapter 41 makes no mention of lateralised symptoms.

☞WWW☜ 8:7

The problem of how many patients would be needed to discover the association is straightforward. Think about the fact that three-quarters of the cases of speech loss have their brain damage on the left side. If language showed no particular association with one side or other of the brain then one would expect 50% to have damage on the left side[1]. How many cases would one need to be confident that the true proportion was indeed 75% and not 50%? It is a bit like those problems so beloved of statistics teachers. I have two coins. One is fair, so that heads and tails are equally likely. The other is biassed, and I have doctored it so that three-quarters of the time it comes down heads. I take one coin from my pocket and toss it. Which is it? It comes down heads. Which coin is it likely to be? Who can say? I toss it again, and again after that, and each time it comes down heads. On the fourth time it comes down tails. Three heads out of four tosses. Does that mean it must be the biassed coin? Hardly. If I toss an ordinary, fair, unbiassed coin four times then on a quarter of occasions I will get three heads and on one in sixteen times I will even get four heads. Using what in statistics is known as a 'power calculation', then in order to be 90% certain of finding evidence that the coin is biassed or not one would need to toss it about 40 times[2].

At some point in a statistical calculation the evidence forces one to reject what statisticians call the null hypothesis. I am always reminded of that scene at the beginning of Tom Stoppard's *Rosencrantz and Guildenstern are dead*, when, despite the fact that normally, "a coin showed heads about as often as it showed tails", that morning, "Ninety-two coins spun consecutively have come down heads ninety-two consecutive times"; something was clearly wrong, different, untoward. The probability of a fair coin showing ninety-two consecutive heads is 2.02×10^{-28}. Guildenstern comments, "A weaker man might be moved to re-examine his faith, if nothing else at least in the law of probability".

Statistical analysis does make one wonder about the work of Dax, who reported forty patients, *not one* of whom had brain damage on the right side. It is all a little suspiciously too good, and reminds one of R.A. Fisher's comment that the 3:1 ratios reported by Gregor Mendel in his famous studies on pea-plants were far too good to be true (see Pilgrim, 1986). In comparison, Broca was extremely cautious, commenting after finding that eight cases all had left sided lesions, "I do not dare to draw any conclusion from this and am waiting for new data" (Schiller, 1979 p.194).

☞WWW☜ 8:8

The case was reported by Dr Prevost, the Head Physician from the Geneva Hospital, at a meeting of the Physical and Natural History Society in London on Jan 20th, 1876

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[1] Throughout these calculations the assumption is made that right and left sided brain damage is equally likely. To a first approximation it is – see for instance Table 21 of McManus (1985a).

[2] Calculated using *Statpower*, two-tailed, one-sample test of a proportion, null hypothesis P=.5, alternative hypothesis P=.75, alpha=.05, power=.9. The actual N required is 39.

(Anonymous., 1876). Prevost had been in London in 1868 when he saw an aphasic patient with Hughlings Jackson and advised Jackson to ask if the patient was left-handed. – see Jackson(1868).

Broca himself introduced “the special name”, 'aphemie' in his 1861 paper; the term aphemia was first used in English in 1864. The modern French term 'aphasie' was introduced by Trousseau in 1865, since 'aphemie' in Greek meant 'infamy', “which was clearly inappropriate”, and after consulting a Greek Hellenist he introduced the term 'aphasie' (Hécaen & Dubois, 1969 p.193); the term 'aphasia' was first used in English in 1867 (Schiller, 1979 pp, 178, 200). As Schiller points out, the term 'Broca's aphasia' is a “bastard term”.

☞WWW☜ 8:9

Although this syndrome is typically called Wernicke's aphasia, and Wernicke did indeed produce a good description in 1874 (see Eggert, 1977), a few years earlier Bastian (1869) had described what has been called Jargon Aphasia, and is essentially the same condition (Christman & Buckingham, 1991).

The paper by Osborne (1834) is full of fascinating details about the patient. The lesion was probably in the left half of the brain since “when he put out his tongue, it was protruded towards the right”.

Osborne's case also appeared in Aldous Huxley's *Point counter point* (1996 p.391):

> “Philip was dining alone. In front of his plate half a bottle of claret and the water jug propped up an open volume. ... The book was Bastian’s *On the brain*. ... Halfway through the fish, he came upon the case of the Irishman who had suffered from paraphasia ... The physician had asked the patient to read aloud a paragraph from the statutes of Trinity College, Dublin. ... Marvellous! Philip said to himself ... What style! What majestic beauty! The richness and sonority of the opening phrase! 'An the bee-what in the tee-mother of the trothodoodoo' “.

The book was actually entitled *The brain as an organ of mind* 1880. Neither Bastian nor Huxley copy the original exactly, as is shown in the misattribution of the statutes, and other minor errors (McManus, 2001a).

☞WWW☜ 8:10

Crampton (1833a, 1833b) recognises that although many of the words used are erroneous, they are often not random: “Sometimes (as in the last instance) one could trace the association of ideas through which he was led to the misnomer: stirabout and buttermilk being associated in the mind of every man of his class in this country; but in the greater number of instances, no such association could be traced...”(p.209).

☞WWW☜ 8:11

For good reviews of the different types of aphasia types see Damasio (1992a) and Code (1991).

The study of Indefrey *et al* (1998a), was unpublished but reported by Hagoort *et al* (1999).

There is far from universal agreement on the precise localisation of Broca's area, Broca himself describing what is now called Brodmann's area 44, with other workers describing areas 44 and 45, or 44, 45 and 47 (Uylings et al., 1999). The area responsible for grammatical analysis seems to overlap a part of area 45.

☞WWW☜ 8:13

The emphasis in the quotation from Jackson (1874) is present in the original. Jackson particularly attributes the recognition of objects to the posterior part of the right hemisphere as opposed to linguistic functions which are in the anterior part of the left hemisphere. Later in 1876 he also describes the right hemisphere as the seat of “visual ideation” or “imperception” (1876).

☞WWW☜ 8:14

There is also a left-hemisphere (or more precisely, a verbal or symbolic) way of solving the problem as well. Since a cube is three-dimensional and the sides are at right-angles to one another, that is they are orthogonal, then each dimension must have two sides, one at each end, and hence there must be three times two equals six sides altogether. A corner is at the intersection of all three dimensions, and the three lines making the corner can each come either from a positive or a negative direction. There are eight possible combinations of three positives and negatives and hence eight corners. And so on. The nice thing about the verbal approach is that is generalised very easily to a four-dimensional cube, a hypercube; or even one with five, six or however many dimensions. Not many people can visualise them.

☞WWW☜ 8:15

An excellent introduction to the problems of agnosia can be found in the detailed case history of 'John' by Humphreys and Riddoch (1987). 'To see but not to see' is a superb summary of the problem.

The picture of Einstein is difficult to see in part because it is printed upside down, a feature I have exploited here to reduce the risk that the reader sees the portrait too quickly. There are probably specialised centres in the brain for face perception, some in the right hemisphere. One of the very interesting problems of face perception is why it is so difficult to see faces upside down (Bruce & Young, 1998 pp.158-160).

☞WWW☜ 8:16

I particularly relish Dr P's comment that “It would contain its contents” (Sacks, 1985 p.13). One could imagine Philip in *Point counterpoint* waxing lyrical over the phrase. In a footnote Sacks also explains that, “Later, by accident, he got it on, and exclaimed, 'My God, it's a glove!'”. The case history also makes it clear that Dr P shows left side neglect.

☞WWW☜ 8:17

Inability to dress herself properly was one of the symptoms reported in Hughlings Jackson's 1876) early case of right hemisphere damage. See the historical review by Hécaen and Albert

(1978 pp.106-7) for a discussion of whether dressing apraxia is a separate syndrome in its own right.

☞WWW☜ 8:18

That the musical quality of speech is affected differently by the two hemispheres can be seen on Wada testing, where anaesthetisation of the left hemisphere prevents a patient from speaking although they can still sing (and can even sing the words of songs which they are unable to speak, Gordon & Bogen, 1974). Conversely the ability to sing though is removed after anaesthetisation of the right hemisphere, although words can still be spoken normally.

☞WWW☜ 8:20

An additional intriguing aspect of these drawings is that pre-operatively P.S. has drawn the cube as most right-handers would do, so that the front of the cube is to the left-hand side, with the back sloping away to the right. Post-operatively though the drawing by the left hand now seems to be mirror-reversed, the front surface of the cube being to the right of the drawing, with the other sides sloping away to the left. It is a mirror-image in other words, which is what one might expect the left hand to do.

One does not even need to damage the entire corpus callosum to find the pattern of deficit seen in P.S. Heilman *et al* (1984a) described a similar result in a patient with a localised area of damage to the callosum due to an aneurysm of the anterior communicating artery (see Watson *et al* (1985b) for details of the lesion).

☞WWW☜ 8:21

The fourteen right-handed patients were receiving ECT as part of the treatment of manic-depression or schizophrenia. Although the authors comment that this may have meant the answers they gave were not typical of normal thought, they do emphasise that in the control condition all of the subjects answered the questions properly in a logical fashion (Deglin & Kinsbourne, 1996).

☞WWW☜ 8:23

For further details on Dickens see my recent paper in *The Lancet* (McManus, 2001b).

One possible diagnosis for Dickens' heart disease is atrial fibrillation, which would be helped by the digitalis he was prescribed, and can also be responsible for small emboli which can affect brain functioning if they block the circulation.

Watson was undoubtedly one of the premier neurologists of the day, the fifth edition of his textbook of 1871 showing he was well up to date on recent work, particularly in its copious citation of the works of Hughlings Jackson then only just gaining his reputation. Jackson was later to repay the compliment, in his 1878 paper referring to Watson as one of those who had particularly contributed to the study of aphasia, and particularly referring to a case in which Watson clearly distinguished automatic and propositional speech (Jackson, 1878). Given Jackson's love of the novels of Charles Dickens (Critchley & Critchley, 1998 p.176), and his interest in neuro-ophthalmology, it is surely one of the great lost opportunities in neurology,

that Watson did not ask Jackson to see Dickens, when perhaps he might have described his symptoms of neglect.

☞WWW☜ 8:24

The first, very brief, mention of neglect was by Hughlings Jackson (1876, Halligan & Marshall, 1993), who at that time was a young neurologist with an interest in ophthalmology, working in London (Critchley & Critchley, 1998).

Neglect dyslexia was itself hardly studied until about two decades ago, Ellis *et al* (1993 p.233) pointing out that until the mid-1980s almost all accounts of neglect dyslexia treated it as just being part of neglect in general.

A rarer error that can occur in neglect dyslexia is that letters are added, as in LOVE being read as GLOVE (Behrmann, 1994a).

An interesting question for interpreting Charles Dickens' symptoms as neglect dyslexia is that most patients with neglect dyslexia do not seem to have insight into their problem, whereas Dickens clearly did, or he could not have described it so accurately to Forster. However it is clear that most patients do have some awareness of what the proper length of the word should be, and adjust their incorrect readings to take that into account. Dickens was however describing a problem in reading the names of shops, that is, proper names, and for these it is probable that from long experience he would have known what they should be. To give a modern example, if one regularly walks past a shop and then one day sees it is called BLOOMSBURYS rather than SAINSBURYS or PIEBALDS rather than McDONALDS, despite the logos, the layout, and the things sold all being the same as usual, then something may well strike one as odd.

☞WWW☜ 8:25

Whether neglect dyslexia and the more common generalised visuo-spatial neglect are separate, dissociable conditions, or whether neglect dyslexia usually also involves generalised neglect is not at all clear at present (Behrmann, 1994a).

The details of Fellini's illness are described by Chandler (1996), and by Cantagallo and Della Sala (1998b), who had permission from Fellini's sister and the Fellini Foundation to report the clinical details of the case. That Fellini had both coronary artery disease and cerebro-vascular disease is perhaps not surprising given the strength of his family history:

> "Heart trouble and strokes run in my family. My mother's brother had a stroke and couldn't speak. My father's brother, my own brother, Riccardo -- all of them died of these problems...".Chandler, 1996 p.365

The cerebral lesion, at the junction of the temporal and the parietal lobes, was probably due to a thrombosis of a branch of the middle cerebral artery.

☞WWW☜ 8:26

Neglect seems to occur much more frequently after right brain damage than left (Bowen, McKenna, & Tallis, 1999). The situation is though complicated by the fact that within a few days of a stroke neglect is very common (60-70%) in both right and left brain damaged

patients (Stone et al., 1991), but that neglect following left brain damage rapidly resolves, resulting in what Ian Robertson has called 'The paradox of neglect' (Robertson, 1993). Occasional examples of right-sided neglect do seem to occur particularly in left-handed patients (e.g. Caramazza & Hillis, 1990).

Although traditionally neglect has been described in terms of visual neglect, there is recent work suggesting that there is also neglect of the left side of auditory space, which is also associated with right parietal lesions (Bellman, Meuli, & Clarke, 2001; Marshall, 2001).

☞WWW☜ 8:27

The meaning of 'Vai a menga' is less than clear, and the translation by Cantagallo and Della Salla (1998b) of 'Forget it!' is perhaps too polite. 'Menga' is not a word in Italian, and one possible explanation is that Fellini was trying to write 'Vai a ramengo' – Go to hell! – and that his left neglect meant that he omitted to write the first two letters of 'ramengo'. Why he also put an 'a' on the end instead of an 'o' is not clear but may be a carryover from 'meta'. Interestingly 'ramengo' probably comes from 'ramingo', to wander, which is precisely what the half-way mark has done.

☞WWW☜ 8:28

In a famous description of patients neglected one half of space in memory, two patients who lived in Milan were asked to imagine they were standing in the Piazza del Duomo, on the side directly opposite the Cathedral, the Duomo. Asked what buildings could be seen, they named only those down the right hand side of the Piazza. When next asked to imagine they were standing on the steps of the Duomo looking out at the Piazza they then correctly described all the buildings down what was then the right hand side; in other words the ones neglected previously (Bisiach & Luzzatti, 1978).

☞WWW☜ 8:30

The division in neglect is often not precisely at the middle, and more detailed studies suggest that there is a gradient of neglect which gets more severe the further one moves into the left half of the object. For an example see Behrmann 1994a.

That the problem in neglect is one of attention and not merely one of sensation is seen from the phenomenon of extinction. If a simple object is placed on the right hand side it can be seen, and likewise if an object is placed just on the left-hand side it can be seen. But if the two are presented at the same time then the patient only reports seeing the one on the right, the left-hand one being neglected. This provides a simple bedside test, the doctor asking the patient to close their eyes and say when they feel their hands being touched. When the right hand is touched the patient reports it, as they do when the left hand is touched. However when both are touched at the same time, only the touch on the right hand is reported.

The stroke of the 59 year old patient was a large lesion in the right temporo-parietal area, and had occurred two years previously (Marshall & Halligan, 1993).

☞WWW☜ 8:31

I had hoped to include in the book the four very fine self-portraits by Anton Räderscheidt, who had a right-sided stroke with neglect, and in which not only can the neglect be seen but also visible is his recovery over a period of many months. They can be seen in colour in Wurtz (1982a). Unfortunately the copyright holders would not allow them to be reproduced in monochrome. Other examples of neglect in artists, in addition to Räderscheidt and Greenshields (Halligan & Marshall, 1997), are Lovis Corinth (Parkin, 1996 Cover illustration), and several who have not been named but for whom detailed analyses have been carried out (Marsh & Philwin, 1987, Schnider et al., 1993, Vigouroux, Bonnefoi, & Khalil, 1990).

☞WWW☜ 8:32

Anosognosia was apparently first described by Seneca the younger, the first century AD Roman philosopher, in a letter:

> "You know that Harpastes, my wife's fatuous companion, has remained in my home as an inherited burden ... This foolish woman has suddenly lost her sight. Incredible as it might appear, what I am going to tell you is true: She does not know she is blind. Therefore, again and again she asks her guardian to take her elsewhere. She claims that my home is dark." (Prigatano, 1996 p.81).

Anosognosia is surprisingly frequent, being found in 15% of a series of patients with a first stroke (Ghika et al., 1999), and 30% of patients with right hemisphere strokes (Stone, Halligan, & Greenwood, 1993)..

In quoting Fellini's description of his left arm I have changed "asparagi" to "asparagus", which reads slightly better.

Although Dickens did not have a strict anosognosia, not having a hemiplegia, there is nevertheless a strong case that he showed denial of a whole range of bodily symptoms McManus, 2001b.

The Romanian patient had several other symptoms of parietal lobe disorder, including a left-sided neglect (Façon, Wertheim, & Mestes, 1960).

Although it has been conventional for nearly a hundred years to regard neglect as a symptom of parietal lobe disorder, it was only in 2001 that it was realised that was not the case. Many patients with neglect show visual field disorders, and that seems to have misled researchers. Patients with a pure neglect and no field disorder have lesions adjacent to the parietal lobe, in the right superior temporal cortex, whereas those with field disorders do indeed show parietal lobe lesions, probably due to damage to the underlying optic radiation (Graziano, 2001; Karnath, Ferber, & Himmelbach, 2001). Although an extremely interesting result which in particular resolves the problem of reconciling human data with experimental lesion studies in monkeys, in practice it gives little serious difficulty in regarding the parietal lobe as the seat of these disorders since the area is immediately contiguous to the parietal lobe and many patients have quite large lesions (Fellini for instance being one).

☞WWW☜ 8:34

The lateralisation of olfaction is made more complicated because the flow of the right and left nostrils tends to alternate over a cycle of several hours, first one nostril and then the other taking in more air. The nostril with the greater flow rate is more sensitive to odorants of different sorption (Sobel et al., 1999). Intriguingly there is a long tradition in Yoga of breathing in specifically through one nostril or the other in order to achieve different meditative states (Gore, 1991), and a suggestion that breathing through just one nostril can enhance right or left hemispheric modes of processing (Morris, 1998).

The precise nature of the deficit in Gourmand Syndrome (Regard & Landis, 1997), is controversial, perhaps having obsessional features, or being related to a failure of impulse control (Regard & Landis, 1998) or to a heightened drive associated with hypomania (Cockrell, 1998).

A recurrent finding in the literature on the lateralisation of music is that musicians and non-musicians differ in the hemispheres they use for tasks, difficult melodies being recognised more easily in the right hemisphere of non-musicians but the left hemisphere of experienced musicians (Messerli et al., 1995), suggesting that there is a sense in which training literally helps in recognising the 'language' of music, a left hemisphere process. See also Damásio and Damásio (1977), Bever (1974), Fabbro *et al* (1990), and Piro (1993).

Rhythm is probably related to speech dominance rather than handedness (Ibbotson & Morton, 1981).

The situation for absolute pitch may be more complicated than was originally thought (Zatorre et al., 1998).

Although 'wine, women and song' always quoted in English with 'women' in the plural, the phrase is attributed to the Protestant theologian, Martin Luther, as “Wein, Weib und Gesang”, wine, *woman* and song; “Who loves not woman, wine, and song / Remains a fool his whole life long”.

In the study of sexual arousal in a scanner (Stoléru et al., 1999), we are told that the films were “tasteful with good actors” (Day, 1999), as one might hope in Paris, and that "a curtain was installed around the tomograph to ensure that the subject's privacy would be respected". For those who feel think that is all a bit too near the bone for a scientific study, such virtual sex is still far removed from the real thing which was managed by some intrepid Dutch researchers. Sex in a scanner was not easy as scanners are pretty small, being designed for single occupancy, and so the subjects were chosen to have "a small to average weight/height index”. (Schultz et al., 1999). The advent on the market of Viagra (sildenafil) was also a contributor to success as it allowed the men to maintain an erection long enough for the scanner to capture the image.

☞WWW☜ 8:35

In figure 14, it might be worried that the left hand side is more salient because in the West we are used to reading from left to right, and so our eyes tend to go to the left hand side of the page. It is a nice idea but probably wrong. Nicholls tested it by looking at a group of Hebrew

students who read from right to left and he found exactly the same effect as in Western students who read from left to right (Nicholls & Bradshaw, 1999).

Although it is true that in complete pictures the balance point is to the left, it is somewhat disconcerting that in a more formal experimental setup that objects appear perceptually 'heavier' on the right hand side of the midline (McManus, Edmondson, & Rodger, 1985).

There is an interesting tendency for right-handers to prefer to sit on the right hand side of cinemas, presumably so that they attend better to the screen. The effect is also present in left-handers but somewhat reduced, although still in the same direction, suggesting that cerebral lateralisation is the cause (Karev, 2000).

Of almost 1000 people who were asked about figure 15, Jaynes (1976 p.120) says that about 80% of the right-handers chose the bottom face. However only 45% of an unknown proportion of left-handers (presumably about 10%) also did so, suggesting that a greater proportion of left-handers have reversed cerebral dominance for perceiving emotion. The faces are also reproduced by Paul (Paul, 1990 p.105) where the pictures have been modified and the statistics slightly altered as well. A more formal test has been produced by Levy *et al* (1983); see also Harris and Snyder (1992b). It is possible that some of the effect may reflect scanning habits derived from language, one study suggesting that readers of Hebrew, Arabic and Urdu showed no tendency to choose the left-hand half, although neither did they tend to choose the right hand half, suggesting that perhaps both scanning and hemispheric specialisation are important (Eviatar, 1997). Another study found a somewhat different result, with readers of Urdu having a reversed pattern compared with readers of Hindi (Sakhuja et al., 2001).

☞WWW☜ 8:36

Although the crucial experiments are usually attributed to Kimura (1961) and Bryden (1962), earlier work was also done by Cherry (1953) and Broadbent (1954). For an excellent overview of dichotic listening see Bryden (1982b). It is commonly presumed that only dichotic techniques can reveal hemispheric effects. However there have been many monaural studies which have also found ear differences (Henry, 1979; Henry, 1983).

Dichotic listening tests have been bedevilled since their introduction by the fact that the subjects are aware of hearing different words on the two ears, and therefore they can choose to attend preferentially to one ear or the other. Kinsbourne (1975) has argued that the laterality effects are principally the result of a swing in attention, activation of the left hemisphere in expectation of hearing words sending attention to the right side of space. That theory is probably rejected by the very elegant experiment of Bulman-Fleming and Bryden (1994b) in which right and left hemisphere effects are obtained simultaneously. Fused dichotic words also avoid the problem since although different stimuli are presented to the two ears they are so closely matched in time that the subject hears only a single word which perceptually is in the centre of the head; nevertheless the words on the right ear are heard preferentially (Wexler & Halwes, 1983), and there is a close correlation with Wada testing for language dominance (Zatorre, 1989, Fernandes & Smith, 2000).

☞WWW☜ 8:38

Broca himself was aware of the theoretical possibility that there were some people who had language in the right hemisphere (and a left hemiplegia), and he acknowledged that,

> "Just as there are left-handers in whom the inherent pre-dominance of the motor activity of the right hemisphere confers a natural and irreversible pre-dominance to the activity of the left hand, so in the same way it is conceivable that there may be a certain number of people in whom the inherent predominance of the convolutions of the right hemisphere will reverse the order of the phenomena I have just described." (Broca, 1865; translation Hécaen & Piercy, 1956).

The sliding between handedness and right hemispheric language makes it look as if Broca is suggesting that the two are associated. However as Eling (1984b) has emphasised, that was not his meaning. Broca continuing,

> "But I don't want to conclude but there must be any agreement between these two categories of exception; because it doesn't seem necessary to me that the motor part and the intellectual part of each hemisphere must be associated, one with the other..." (my translation).

The emphasis in the quotation from Hughlings Jackson (1866) is in the original.

This idea that left-handers are the converse of right-handers has been variously called the mirror-reversal principle, the conjunction principle and Broca's rule (Harris, 1980, Harris, 1991). I have also used the term Dax's law (McManus, 1979 p.6.9;McManus, 1983), dating it back to Ogle (Ogle, 1871); the term was also used by Critchley (1964). Quite who first enunciated the principle is not clear, although I think it is clear that neither of the Dax's was responsible. Although Broca has generally been cleared of the specific charge (Harris, 1991), there is little doubt that he was very sympathetic to the basic concept. Certainly the idea was common by 1866 and became the established norm for many years after (Harris, 1991).

☞WWW☜ 8:39

William James (James, 1890 vol I: p.39) was actually referring to the damage found in cases of aphasia, but I have substituted 'language' since that is what was to be inferred from the statement.

If one looks at the pattern of cases reported during the eighty or so years after Broca then it is clear that for a long while people were only publishing cases which fitted the scenario that the only patients with right hemisphere language were left-handers; See figure 6.1 in McManus (1979) .

☞WWW☜ 8:40

Luria (1970) was published in Russian in 1947 and not translated until 1970. The concept of latent sinistrality was however also invoked by Russell Brain, one of the leading British neurologists (Brain, 1945), and was clearly extant in the world scientific literature before that.

I criticised Luria's concept of left-handedness in a long, historical paper (McManus, 1983). I found great difficulty in getting the article published, one referee describing it as a character assassination. I was fortunate that Marcel Kinsbourne was exceedingly helpful in eventually getting it into print, and I continue to remain indebted to him for that assistance.

To my knowledge no formal evidence has ever been put forward that the signs of latent left handedness predicted crossed handedness and language dominance. I am reminded when thinking about latent left-handedness of the Freudian concept of latent homosexuality, and the old psychoanalytic joke about the only question is whether a client is homosexual or a latent homosexual, since no other category exists. Latent homosexuality and latent left-handedness were themselves explicitly linked by Fliess (Freud, 1985 p.296).

☞WWW☜ 8:43

To spell out the calculations precisely, the proportions of the four combinations of handedness and language, RL, RR, LR and LL will be 1:0:0:0 for DD, .5625:.1875: .1875:.0625 for DC and .25:.25:.25:.25 for CC. If 10% of the population is left-handed then .64 of the population are DD, .32 are DC and .04 are CC. The proportions of RL, RR, LR and LL are then .83:.07:.07:.03, making 7.77% of right-handers and 30.0% of left-handers have language in the right hemisphere.

☞WWW☜ 8:44

Despite the absolute numbers varying quite considerably according to the techniques used to assess the proportion of right and left language dominance, what was much more impressive was that the relationship between the proportion of right-handed language in right-handers and the proportion in left-handers was much more constant. That suggested that the differences between the different methods of assessment were more to do with definition and measurement error than they were to do with fundamental discrepancies (McManus, 1979,McManus, 1985a).

Although I do not not discuss it in the book, there are probably systematic differences resulting from the study of patients with acute rather than chronic lesions, and that these may well result from many of the patients with chronic lesions no longer being aphasic due to recovery. That can be modelled by a simple extension whereby there are two language centres, which either can be both in the left hemisphere, both in the right hemisphere, or one in each hemisphere. Disruption of either centre by a stroke results in an acute aphasia. However if one centre remains intact, due to it being in the other hemisphere, then recovery can occur. The result is that the incidence of aphasia in chronic patients is far lower than in acute patients. For further details see McManus (1985a).

☞WWW☜ 8:45

Gardner was a forerunner of Wada, developing a slightly different technique, the injection of the local anaesthetic procaine directly into the brain itself; the technique though never really caught on (Harris & Snyder, 1997).

☞WWW☜ 8:46

Although I have implied that the carotid artery provides the blood supply to one hemisphere, to be more precise it is the internal carotid artery which supplies the anterior and middle cerebral arteries, which provide blood to the frontal, temporal and parietal lobes of the brain. The blood to the posterior cerebral arteries mostly comes from the vertebral arteries which are not affected by the Wada technique.

Although injection using a large needle directly ntot he carotid artery is a crude technique it was still being carried out while I was a house surgeon on a neurosurgical unit in the UK in 1975. Patients would be sent off to the X-ray unit and radiologists would stab away at their necks with a distressingly long needle until eventually they managed to put some dye and then some amytal into the carotid artery on that side. And then they would start on the other side. Nowadays a long, thin flexible catheter in inserted into the femoral artery, and then guided up into the internal carotid artery with X-ray monitoring.

Wada eventually became a neurosurgeon at the University of British Columbia in Vancouver, Canada becoming his adopted country.

☞WWW☜ 8:48

Despite its problems, the Wada test have provided many neuropsychological insights when used in patients about to undergo neurosurgery, as for instance in the demonstration that amytal produces a temporary unilateral neglect after injection into the right hemisphere but not the left hemisphere (Spiers et al., 1990), or that anosognosia occurs after right-sided injection (Carpenter et al., 1995). Wada himself had also noticed that patients reported left-right disorientation after left-sided injections (Snyder & Harris, 1997 p.25).

☞WWW☜ 8:49

The technology used in the new method of assessing language dominance had been in use in fetal medicine units for a while; I'd even seen it in action myself a year or so before I read of its use in understanding lateralisation, but still the idea did occur to me. The method was used in the fetal medicine unit to assess the blood flow through the brains of my daughters, who were still then *in utero*. Identical twins often suffer from the problem known as Identical Twin Transfusion Syndrome, in which the blood vessels of the two twins become interconnected in the placenta. Because the twins are genetically identical the blood vessels interconnect with abandon, and, if things go badly, the arteries of one twin can get connected to the veins of the other. The result is a chronic haemorrhage from one twin to the other. One becomes severely anaemic and becomes the smaller, while the gets all the blood from its co-twin, and becomes plethoric, bloated and big. Neither benefits either twin. The smaller twin suffers from starvation, whereas the blood in the larger twin can become so thick and viscous because of the red blood cells continually being added to it that it can slow down and even clot, with disastrous consequences. Ultrasound Doppler scanning allows one to measure the rate of flow off the blood in the middle cerebral artery of the fetus and check if it is moving quickly enough. In severe cases it flows slowly or even, during one phase of the cardiac cycle, it flows backwards. Fortunately neither was the case with my daughters.

Knecht's technique (Knecht et al., 2000) is highly reproducible (Knecht et al., 1998a) and also correlates well with the Wada test (Knecht et al., 1998b). Interestingly the proportion of right hemisphere dominant right-handed males (8/77 = 10.4%) was somewhat higher than that of right hemisphere dominant right-handed females (6/111=5.4%). Although the difference is not statistically significant, it is nevertheless much what might be expected.

Based on the figures given in Knecht et al (2000)[3], The 95% confidence for the proportion of right-handers with right-hemisphere language dominance is 2.7% - 9.1%. For the left-handers the 95% confidence interval is 16.2% to 31.3%.

An important paper was also published in 1999 which used functional MRI (fMRI) to assess language dominance in individual normal right and left-handers (Pujol et al., 1999). Of 50 right-handers, 1 (2%) showed right-hemisphere activation, and of 50 left-handers, 9 (18%) showed bilateral or right hemisphere activation[4]. The 95% confidence intervals for right-handers are 0 to 5.9%, and for left-handers are 7.4 to 28.6%.

Knecht and his colleagues have also used their method to look at correlates between atypical language dominance (i.e. right-sided) and other aspects of behaviour (Knecht et al., 2001), such as linguistic ability, academic achievement, or artistic talent, although some of their measures, as of artistic ability, were somewhat limited in their power to detect such effects.

[3] Numbers derived from the table in figure 3, with the group with laterality coefficients between -25 and +25 equally divided between right and left-handers.

[4] Numbers based on the data in figure 2 on p.1039, right hemisphere dominance being based on a language laterality index of ≤ 0.

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